THE GEOLOGIC RELATIONS OF THE HUMAN RELICS OF LANSING, KANSAS.

UNDER the title "A Fossil Man from Kansas," Professor Williston announced in *Science* of August 1, the discovery of human remains in alluvium near the mouth of a ravine opening on the flood plain of the Missouri river near Lansing, Kansas. He gave a careful description of the circumstances of the discovery, of the nature and condition of the skeleton, and of the enveloping deposit. He confidently excluded all forms of intrusion and of burial by creeping or sliding, attested fully the true fossil nature of the remains, and referred them to that stage of the postglacial period when the Missouri river was running forty or fifty feet higher than now.

Previous to this there had been references to the discovery in the press, which had attracted the attention of Mr. M. C. Long, curator of the museum of Kansas City, who visited the locality, secured as many of the bones as practicable, brought the matter to the attention of neighboring scientists, and through them to the scientific world.

In *Science* of August 29, under the title, "Man in Kansas During the Iowan Stage of the Glacial Period," Mr. Warren Upham gave a brief statement of his observations and conclusions based on a visit to the locality on August 9, in company with Professors Winchell, Williston, Haworth, Mr. Long and others. Mr. Upham regarded the overlying deposit as loess of the Iowan age, and concluded that the skeleton had been "entombed at the beginning of the loess deposition, which would refer it to the Iowan stage of the glacial period, long after the ice sheet had receded from Missouri and Kansas, but while it still enveloped northern Iowa and nearly all of Wisconsin and Minnesota."

In the *American Geologist* for September, he presented the subject with greater fullness under the title, "Man in the Ice Age at Lansing, Kansas, and Little Falls, Minnesota." As before, the inhumation was referred to the Iowan stage of glaciation,

comparison was made with other human relics regarded as dating from the glacial period, and estimates in years of the duration of the several glacial stages were added.

In the same number of the *American Geologist*, Professor Winchell commented at length editorially upon the Lansing skeleton. He referred with implied approval to the article of Mr. Upham,

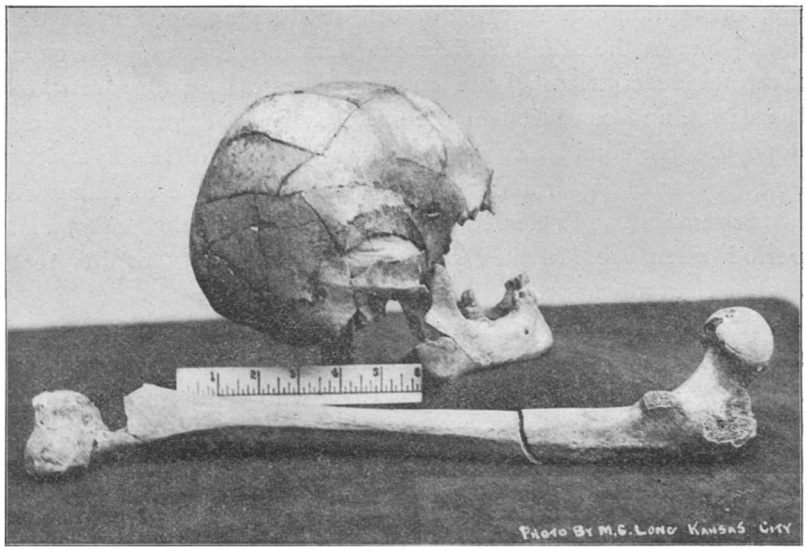

FIG. 1.—Side view of skull and femur found in the tunnel. From a photograph furnished by Mr. M. C. Long.

supplied additional information relative to the history of the discovery, to the deposit embracing the relics, and to the nature and condition of these. He regarded the main material penetrated by the tunnel as common loess, and located the skeleton in the unstratified limestone débris that lies below it. "It is hence preloessian, but probably not much older that the loess." He discussed at some length the age and relations of the loess, and concluded: "It will require, therefore, considerable further and careful examination of the loess sheets of Iowa, and of their relations to the till-sheets, as well as the marginal features of the till-sheets themselves, to enable any one to fix with any certainty

the age of the Lansing skeleton more exactly than is above indicated. That it dates from glacial time, at some remote point in the complex history of that age, is about all that can be affirmed from the present state of knowledge of the drift deposits."

On September 20 the locality was visited by Professors Samuel Calvin, W. H. Holmes, Erasmus Haworth, R. D. Salisbury, W. C. Hoad, Dr. G. A. Dorsey, Messrs. M. C. Long, F. R. Feitshaus, Martin, R. T. Chamberlin, and the writer. This visit was made at the request of Dr. Haworth and other geologists. A second visit was made on October 26 at the request of Professor Holmes and Mr. Gerard Fowke to inspect the excavations which the latter had made under the direction of the former. Mr. Long, Mr. S. J. Hare, and Dr. Haworth joined in this inspection. The Messrs. Concannon tendered all necessary privileges, as well as aid and hospitality. The following discussion is based on the data collected in these visits.

PRELIMINARY CONSIDERATIONS.

While the development of the science of river action in most of its phases is one of the gratifying achievements of recent decades, it is still to be confessed that a certain few of its aspects are among the laggard features of our science, and, as it happens, these are the ones most critically involved in the interpretation of the Lansing remains. It may not be amiss, therefore, at the outset to consider academically these special phases of fluvial action so far as essential to the present discussion.

1. *Scour-and-fill.*—One of these scantily appreciated subjects is the great depth and important function of scour-and-fill in certain of our large rivers. In this action both erosive and depositional work proceed *simultaneously*. It is well recognized that erosion and deposition may take place simultaneously in the stream bed and upon the flood plain, but the great depths and wide extent to which certain river bottoms are scoured out and promptly refilled is not always realized, nor the quick and constant reversals of this action. This is true especially of powerful rivers that flow upon a deep bed of loose material, as is the case with most of the large rivers whose bottoms were built up by

glacio-fluvial deposits during the ice age. The great examples are the larger members of the upper Mississippian system, and pre-eminent among these, the Missouri river whose bottom deposit is mainly sand and silt of an unusually mobile type. The vain struggle of the United States engineers to restrain the destructive shiftings of this river within bounds amenable to navigation and to permanent improvement on its banks, has brought out data which amply illustrate this profound instability, but this can only be fully appreciated by a detailed study of the reports of the chief of engineers.[1] Mr. L. E. Cooley, in his report for 1879, (p. 1066), makes the following among many other pertinent statements:

"To understand the difficult nature of the problem presented here [Eastport bend, on the Missouri river much above Lansing, but where the conditions are not essentially different], it is necessary to consider that at high-water, the banks are under water to a depth of three or four feet, and the current velocity is as great as seven or eight miles an hour. The erosion of the banks for several years past has been at the rate of about 1,100 feet per annum. When this was stopped by our revetment, a tremendous scour was set up, carrying the bed of the river thirty or forty feet below its normal position; in fact, the scour undoubtedly extended to the solid rock underlying the valley." And again (*loc. cit.*, p. 1071), "In many of the borings which have been made here, indurated clay balls with vegetable matter covered with a coating of sand, along with a motley collection of gravel stones, are found within a short distance of permanent strata. A precisely similar collection containing gumbo balls in a soft state was dredged from sixty feet depth at the works. These balls are from cutting banks, and the proof is conclusive that since the river has been running in silt banks as at present, scour has occasionally, at least, reached permanent strata at seventy to ninety feet depth."

Mr. Concannon informed me that eleven years ago the

[1] Professor Todd has called attention to some of these remarkable facts in his bulletin on the "Moraines of Southeastern Dakota and their Attendant Deposits," *Bull. U. S. Geol. Survey*, No. 158, pp. 150, 151.

engineers found a depth of water of ninety feet in the Missouri at a point about a quarter of a mile from his house, in what was then the channel of the river, but which is now abandoned and filled so that water covers the spot only at the highest stages of the river. Until about eight years ago the course of the river lay near the mouth of the valley in question, but is now diverted to the opposite side of the bottoms.

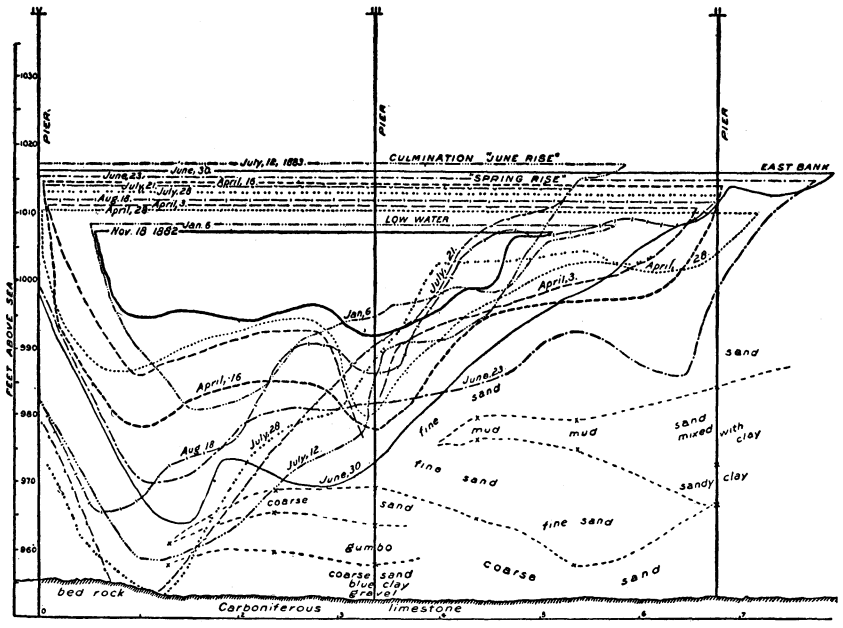

FIG. 2.—Diagram of the changes in the bottom of the Missouri river at Blair Bridge in 1883, as recorded by Engineer E. Gerber. Figure taken from Todd's *Bulletin United States Geological Survey*, No. 158, p. 151.

An accurate demonstration of the extent and rapidity of bottom changes is furnished by the accompanying diagrammatic record of the soundings at the Blair bridge, Nebraska, at the intervals indicated, in the year 1883, quoted by Todd on the authority of Mr. E. Gerber, assistant engineer F. E. & M. V. railroad.

An inspection of this will show that a skeleton might have been deposited on the surface of the Carboniferous rock bottom, much as in the case of the skeleton at Lansing, on the 28th of

July, 1883, and have been buried in alluvium as deeply as the Lansing skeleton by August 18, only twenty-one days later. Without doubt, within a few years it would be covered by sixty feet of alluvium through the migration of the channel of the river.

2. *The prevalence of this profound reworking.*— To illustrate how fully and effectually the whole of the bottoms of the Missouri river in this region are involved in its meanders and their shiftings, and how its bordering bluffs are being forced to retire by the impingement of the currents at its bends, a reduced copy of the United States Engineers' map is here introduced (Fig. 3), the section being about forty miles north of the locality in question, but representative of the conditions in all this portion of the river. It will be noted that practically the whole valley bottom is involved in the migrating loops, and that every part of its silt bed is liable to be disturbed again and again by scour and redeposit; indeed, it is probable that this has happened repeatedly to many portions, if not to most portions of the alluvial filling. It is perhaps not greatly beyond the facts to regard the whole bottom filling as being shifted, step by step down stream by successive scour and fill. This is more especially true of the borders of the bottom filling next the bluffs where the arrest and turn-about of the powerful stream gives the greatest rotatory and deep-disturbing effects.

3. *The absence of the great Dakota system of terraces.*—In the widening of the bottoms thus still in progress doubtless lies the reason why so few distinct remnants of the grand systems of glacial terraces and glacio-fluvial deposits of Dakota, described by Todd,[1] are found in this lower portion of the Missouri river. It is probable that the whole tract once occupied by these, and more besides, is now embraced by this widened, and still widening, zone of lateral encroachment. This is the less remarkable when we recall that the Missouri river was formed by the union of many preglacial streams of various connections whose lower courses were blocked up by the ice invasion so that they were

[1] *Loc. cit.*, pp. 128–140. The general nature of these is given in a later portion of the present paper.

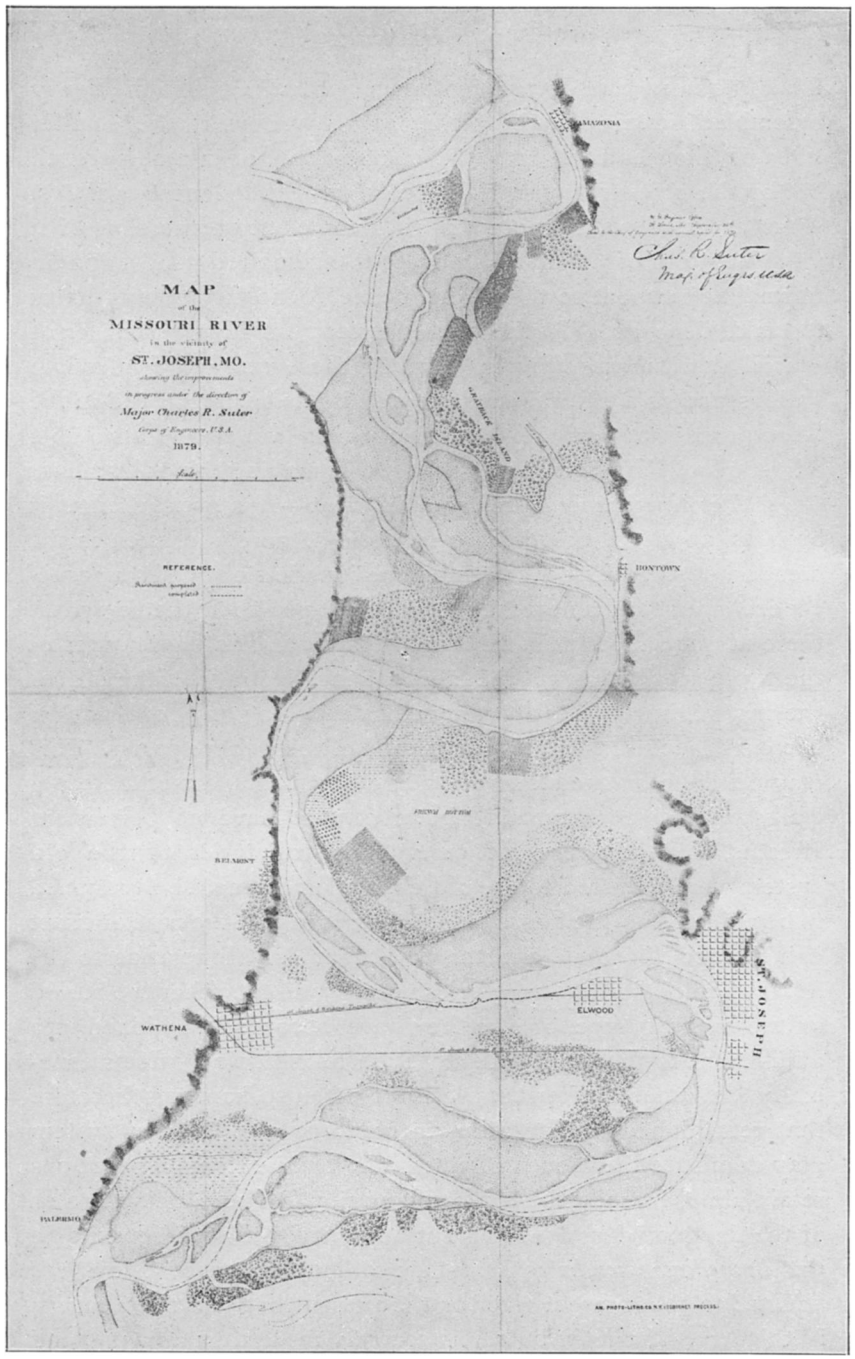

FIG. 3.—Reproduction of map of the Missouri bottoms at St. Joseph, Mo. From the *Annual Report of the Chief of Engineers for 1879.*

forced to unite and flow along the ice border. At first the newly assembled streams flowed either in the valleys of the smaller streams that entered into the combination, or in a new trench cut by the new stream across the cols between the united valleys. Thus at first it would not as a rule come into possession of a valley bottom of capacity adequate to the united floods, and in normal adjustment to them, and hence found little opportunity to make deposits. To the limited extent provided, its burden of glacial detritus was thrown down in these new and inadequate valleys, and as a natural consequence, it has been removed in the later process of working out an adequate valley and a suitable adjustment. The river is still engaged in making this adjustment.

4. *The significance of valley adjustment.*—If a great change is brought about in the drainage system of a region, such as the creation of the Missouri river by the junction of numerous antecedent rivers, and a new channel is developed to fit the new river, there at once arises the question whether the existing features of the valleys tributary to the new channel belong to the old or the new régime. In part they usually belong to both, and it becomes necessary to discriminate between these parts. This may be done by the study of their adjustments, a method especially applicable to small tributaries that have no permanent streams, as in the present case. The tributaries of the old system were adjusted to the old channel and cannot be presumed to be adjusted to the new channel, except in the rare case of exact coincidence of the old and the new channels. In relation to the new system, inherited tributaries usually present either the buried or the hanging type, or else they have become refashioned into adjustment to the new system. Such refashioning affects especially the mouths of tributaries. It often so happens therefore that refashioned configuration in conformity to the new system may dominate the mouth of a tributary, while its upper portions retain almost wholly the old configuration. These facts warn us of the danger of assigning great antiquity to fluvial deposits in the *immediate mouths* of tributary valleys if these valleys are *adjusted* to the present river or the present bottoms; especially is this true if the tributary is scarcely more than a ravine, and

its erosion and deposition are intimately conditioned by its relation to the river. In all such cases there is a strong presumption that the erosions and depositions at the mouth of such a tributary, such especially as have brought it into adjustment to the present and to the recent stages of the river, were contemporaneous with those stages and not accidental inheritances.

5. *Meandering as a cause of alternate erosion and deposition.*— A meandering river with a deep, readily-shifted, bottom-filling of the Missouri type imposes upon its tributary valleys alternate stages of excavation and filling. These result (1) from the action of the aggressive bends of the river loops against the mouths of the tributaries, and (2), the replacement of these, after a time, by the flood-plain peninsulas that lie within the loops. More specifically, it is the alternate cutting of the stream itself, working hard against and under the mouth of the tributary valley, followed by the building up of the river's higher flood-plain across the mouth of the valley. The first causes the waters of the adjusted tributary to erode; the second to make deposits in the mouth of the tributary; for in the first stage the axis of the tributary opens out on the river itself, which may be twenty or thirty feet, or more, lower than the upper flood-plain, and hence the tributary then has its lowest and best opportunity to discharge its waters and their detrital burden. Besides this, the river itself, while in this aggressive attitude, sweeps into the mouth of the tributary in its flood stages and aids in its excavation, and the rushing by of the river's strong current drags out by friction, on the principle of draught, the waters of the tributary, and, by acceleration, aids their excavating action. It is at this stage preeminently that the tributaries cut down their valleys into adjustment with the main stream bed. On the other hand, when the active impinging bend of the river has shifted elsewhere, and in its stead a flood-plain is being built up across the mouth of the tributary the drainage of the latter is checked, and if the tributary be small and its waters incompetent in comparison with the flood-plain aggradation of the river, the valley mouth will be filled to a height corresponding to that of the highest flood-plain. Now, the difference between low water and high water for the

Missouri river is given by Abbott as twenty feet at St. Joseph, above Lansing, and as thirty-five feet at its mouth; its extreme range is somewhat greater than this.

Further, if the mouth of the tributary be blocked by the upper flood-plain beyond the time of the latter's growth the wash from the tributary will build a delta, or fan, upon it, and this further growth will continue until the waters from the tributary valley have built up a suitable gradient for themselves across the flood-plain to the river. This only holds good in valleys of incompetent drainage which cannot cut and maintain a trench for themselves. If the tributary valley has a large, competent stream it will maintain a channel-way across the flood-plain to the river, and less aggradation will result from the shifting of the meanders, but that is not the case in hand.

If excuse for this academic statement is needed it is found in its special application to the case in hand; for either action of the kind just set forth is to be accepted as an elucidation of the case, as in the preferred interpretation that follows, or it is to be shown incompetent for such elucidation before we permit ourselves to go back of this action to earlier agencies. It is a vital principle of good practice that the agencies and phenomena nearest at hand be first considered, and, if the case requires, be eliminated, before recourse is had to more remote agencies. This is peculiarly true when, as in this case, the agencies closest at hand in time have quite certainly swept away the most of a more ancient record in making their own.

THE SPECIAL CASE.

The topographic environment of the relic-bearing deposit.—The site of the human remains is at the bottom of a small, short, rather steep-sided valley opening out on the flood-plain of the Missouri river. More specifically, the valley is less than a mile long, and less than half a mile wide, measured from crest to crest, and is about 160 feet deep at its mouth. The slopes on either hand are rather steep and nearly meet at a rather sharp angle in the axis of the valley, except that this is modified by the channel or dry run which forms narrow bottoms and little bluffs near the mouth,

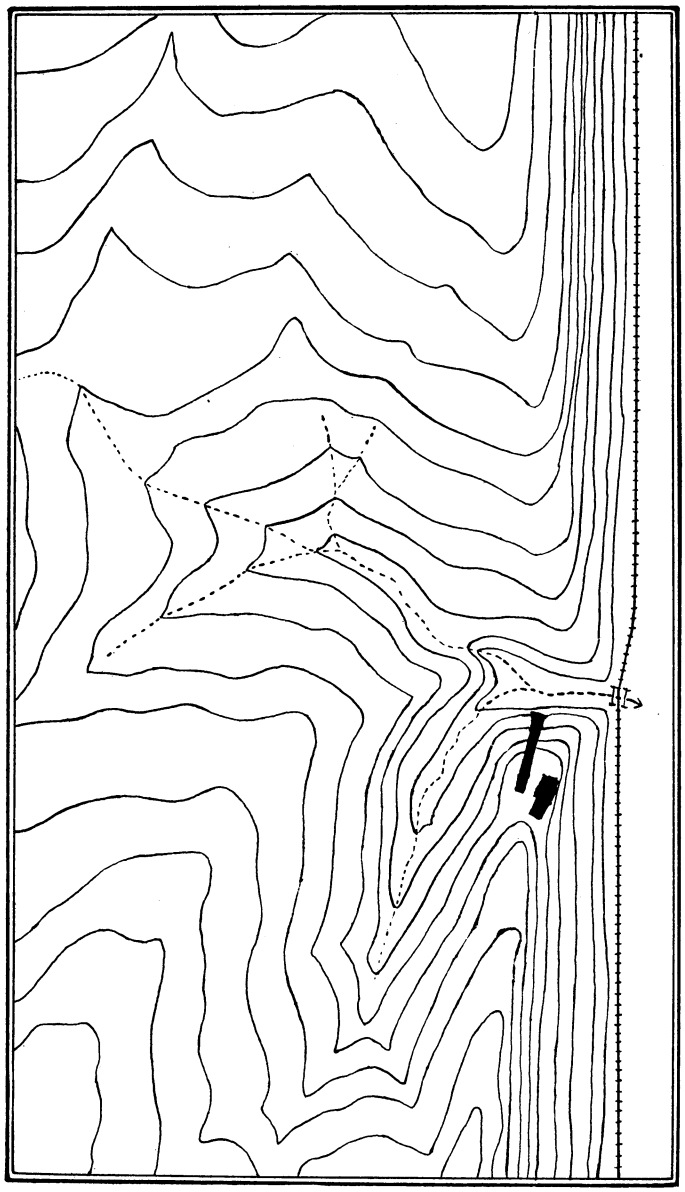

FIG. 4.—Topographic map of the tributary valley at Concannon's. From a sketch by Professor W. H. Holmes.

for the valley is not occupied by a permanent stream. The slope on the southward side is about as steep on the average as can be profitably cultivated; that on the north side is steeper, so that while the upper slope is cultivated the lower slope is left to natural growth and is partially occupied by quarries. On this steeper portion there are some small, vague, bench-like lines of uncertain interpretation; quite likely they are structural features dependent on the alternation of the more and the less resistant layers of the underlying strata. About twenty-five feet from the base of the slope there is an ill-defined bench that seems to be made up

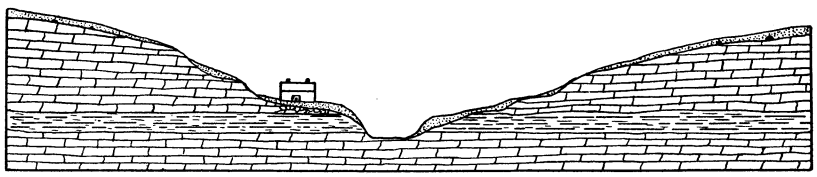

FIG. 5.—Section through the mouth of the tributary valley and the ridges on the north and south. Merely diagrammatic.

of lodgment matter adjusted to a former higher axis of the valley. There is a correspondingly vague bench on the opposite side. The ridges are composed of Carboniferous limestone, mantled by Pleistocene deposits (Fig. 5). The glacial drift is represented by some bowlders and smaller rubbish, but it is so scant and patchy as to be negligible as an element of the topography. The upland surface is mantled with loess and loam, the main portion of which is probably referable to the Iowan stage. The lower slopes are covered by wash from the uplands and by the skeleton-enclosing deposit which lies near the axis of the tributary valley and constitutes the vague benches above mentioned.

The back country is strongly rolling, the valleys fairly sharp, and their debouchures into the Missouri bottoms abrupt but well adjusted, and in their adjustments they represent the several normal types as well as several different stages. The bottoms of the Missouri are sharply defined by bluff faces. This is particularly so where the little valley in question joins it. The Missouri here runs southeastward, and the ridges bounding

the tributary valley on either side have been abruptly truncated by the waters of the Missouri and present a sharp talus face toward the bottoms. The recency of this face is a declared feature and is significant. Where not occupied by rock, the slope is formed of talus marked by slides and slump terraces so new as still to preserve their distinctive features. A very persistent slide terrace runs along the base of the south ridge at

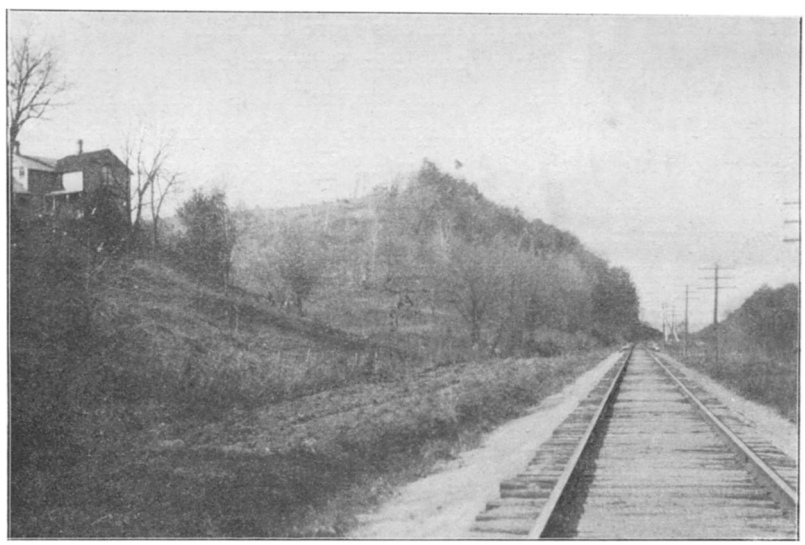

FIG. 6.—View looking northward across the mouth of the tributary valley, showing Concannon's house at the left, and the truncated slope under it, the mouth of the valley just beyond, and in the center the north bluff with its truncated face overlooking the Missouri bottoms, on the edge of which the railroad lies. The bluff is about 160 feet high.

about the horizon of the skeleton's burial, ending nearly opposite it, and about ten rods distant. It is not intended here to suggest an immediate connection between this slide action and the burial of the relics, but merely to show the recency of the Missouri's work across the mouth of the tributary valley and within a few rods of the critical locality. This propinquity is brought into greater emphasis by noting that if a line be drawn from the crest of the talus slope of the north bluff to the crest

of the talus slope of the south bluff, it will run back of the skeleton's site. The significance of this close relation lies in the alternate depositional and aggradational work presumably done by the Missouri river at and in the mouth of the valley when it was truncating the adjacent bluffs on the one hand, and forming the adjacent bottoms on the other, in accordance with the principles of action outlined above. The accompanying contour map and photographs (Figs. 4 and 6–11), with their explanations, make these relations more definite.

The precise locality of the relics is more closely defined by an additional feature. A deep ravine starts near the crest of the ridge bounding the tributary valley on the south, and running nearly parallel with the truncated face overlooking the Missouri bottoms, joins the axis of the valley a few rods west of Concannon's house (see Fig. 7). East of this ravine there was doubtless once a round-back ridge of the usual erosion type with another ravine still to the eastward, but the encroachment of the Missouri has cut away the eastern half and substituted a steep talus slope. There now remains a sharp-edged spur descending toward the axis of the tributary valley, with a talus face on the side next the Missouri bottom, and a more gentle, yet rather steep slope to the ravine on the other side. Following down this sharp-edged spur, it is found to flatten somewhat for a few rods at about sixty feet above the bottom of the valley, much as though the flattened portion might be a remnant of a small terrace, structural or otherwise. Farther on, this breaks down, with rock exposure, for about ten feet to another flattening for another few rods. On this lower shoulder Mr. Concannon's house stands, beyond which the spur ends in a sharp descent of about thirty feet to the dry run of the valley. On the west side of the house the surface descends more gently to the ravine above described. It is under this westward slope, about one hundred feet back from the edge of the talus slope facing the Missouri bottoms, and about seventy feet southward from the little bluff facing the dry run of the valley, that the human remains were found buried about twenty feet deep. These details are given with some tediousness because they bear

upon the interpretation of the time and mode of deposition of the formation embracing the relics.

As already stated, the tributary valley is not occupied by a constant stream, but by periodic run-off. The channel at present is in a slightly aggraded and apparently still aggrading stage. It opens out upon the Missouri bottoms about two hundred feet

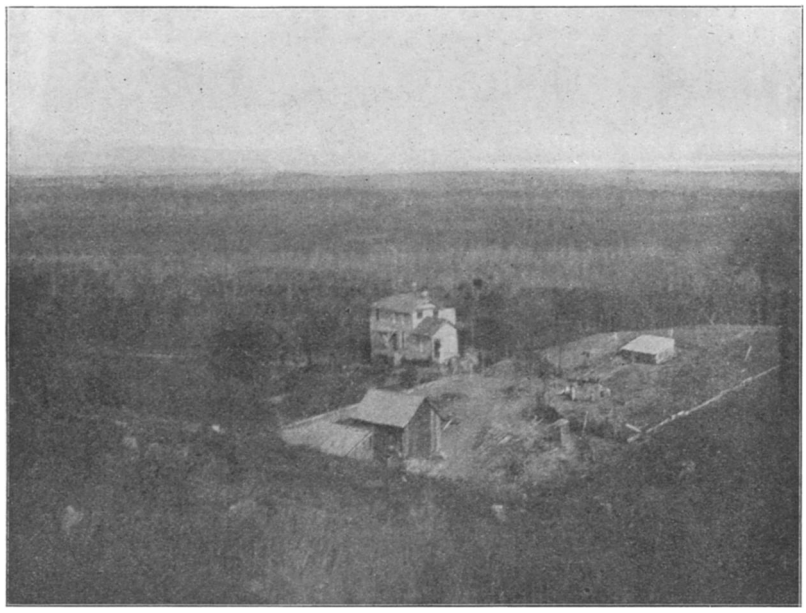

FIG. 7.—View of Concannon's house and environment seen from the south-southwest. In the foreground and center is the ravine leading down from the south, described in the text. The locality of the skeleton is nearly under the small white spot near the dark clump of trees on the slope at the left of the house. The ravine joins the tributary valley just at the left of this and the latter joins the Missouri bottoms in front of the house. The Missouri bottoms stretch across the upper part of the view, with the river (in its new course) and the opposite bluff in the extreme background.

from the locality of the relics, with perfect adjustment, and its recent deposits were slightly fanned out upon the bottoms of the main valley on our first visit, but had been largely washed onward by the rain that intervened before the second visit, illustrating the nature of the present adjustment. The depth of the

aggradation deposit is unknown to me, but it is probably not many feet, as the aggradation stage has but recently been inaugurated by the detour of the river. On the north side the spur next the Missouri bottoms grades down to this lower grada-

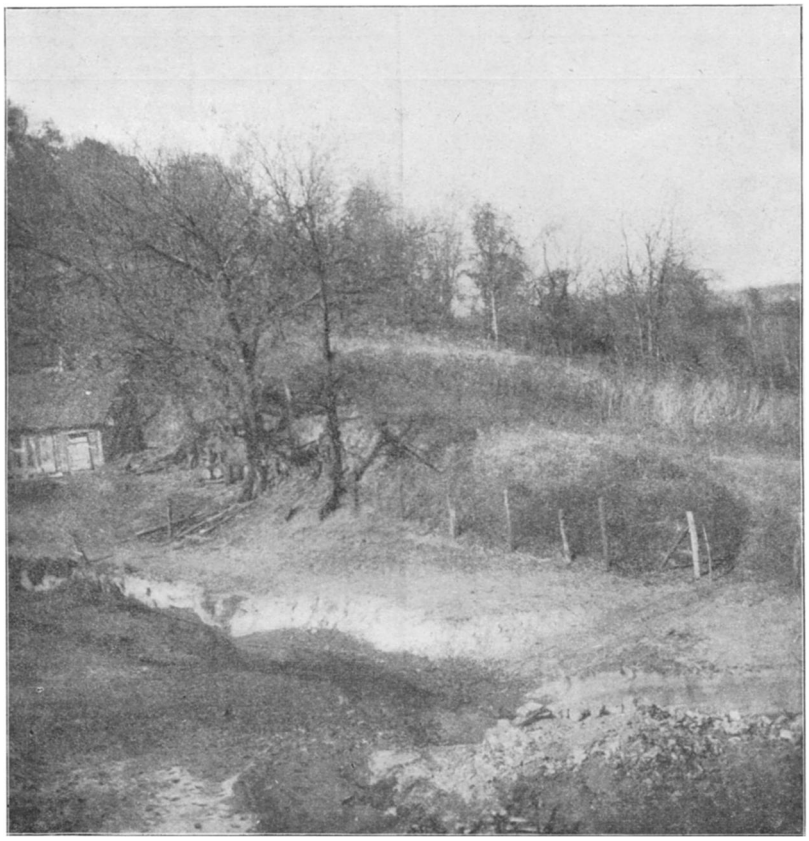

FIG. 8.—View from near the mouth of the tunnel looking northeastward across the bottom of the tributary valley, showing the gradation of the footslope of the north bluff into the Missouri bottoms seen at the right.

tion plain and the combination of lower slope and present bottom deposits is similar to that of an earlier date on the south side which contains the human bones (Fig. 8.)

The present aggrading washes have made a little bottom in the lower twenty rods of the valley, with meanders and little

bluffs where the loops bear against the older deposits of the valley. It is in the face of the little bluff on the south side, and about four feet above the valley bottom, that the mouth of the tunnel that disclosed the human remains is located. The base of the tunnel at its mouth is ten or twelve feet above the

Fig. 9.—View in the mouth of the tributary valley looking out upon the Missouri bottoms and showing the entrance to the tunnel at the extreme right. The material from the tunnel modifies the natural bottom, as seen in the foreground.

adjacent Missouri bottoms (Fig. 9). The lower four feet of the little bluff is formed of a thick bed of Carboniferous limestone; above this there is shale. The tunnel was started just above this limestone and driven back on its gently rising surface. It was carried by the Concannons seventy-two feet back from the face

of the bluff, and at its inner end its base is twenty-one feet five inches below the surface, an air-shaft permitting a tape-line measurement.

The relics found in excavating the tunnel represent an adult who had lost several teeth and a child whose teething stage, according to Professor Williston, implies an age of about nine

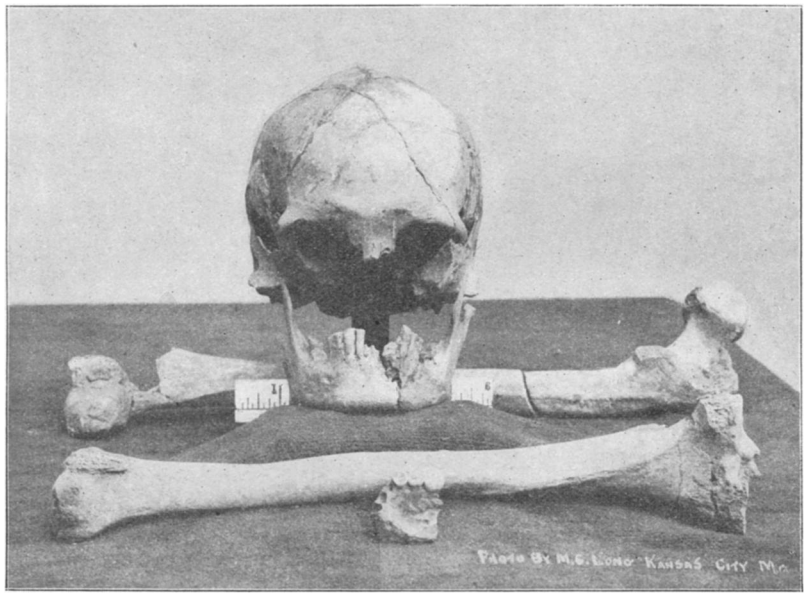

FIG. 10.—Front view of the skeleton of the adult and two of the associated bones, with the fragment of the child's jaw in the foreground. From a photograph furnished by Mr. M. C. Long.

years. The former is represented by a skull, femur, and other bones; the latter only by a fragment of a jaw (Fig. 10.) The bones of the adult are said to have been found near the inner end of the tunnel, and between one and two feet above its base. They were disarranged and at slightly different depths, but it is sufficient for present purposes to locate them at seventy feet from the entrance and twenty feet from the surface. The fragment of the child's jaw was found about sixty feet from the entrance and within a foot of the bottom of the tunnel. These statements relative to the discovery of the bones rest upon the testi-

mony of Michael T. and Joseph F. Concannon, who dug the tunnel. There is no ground to question their authenticity.

The associated deposit.—At the mouth of the tunnel the lower three or four feet of the deposit is composed mainly of limestone fragments and earthy débris, a part of the latter seeming to come from the Carboniferous beds, a part from the glacial drift or the loess, and a part from the river and valley wash; in short, a rather heterogeneous mixture. Some parts are highly oxidized and iron-stained and some parts are relatively fresh and calcareous. At about three feet above the floor on the western side there is a definite layer of dark, highly calcareous clay less than three inches thick, but it does not appear on the opposite side. It is thinner in the inner portion of the tunnel, where the cross cut of Mr. Fowke shows that it rises on the west side and pinches out irregularly within a few feet. The upper part of the deposit at the entrance is a mottled silt of loess-loam aspect, containing occasional stony fragments. Its response to acid is irregular, sometimes giving no obvious effervescence, sometimes a feeble action, and sometimes a prompt and marked response. Sometimes the action is concentrated in definite spots, as though it came from a bit of limestone. The action is not that characteristic of typical loess. Even in the top of the tunnel some limestone fragments were seen seven or eight feet from its base. Even in the inner end of the tunnel the silt is notably mottled, in part irregularly, and in part in bands, more or less horizontal, as though controlled by stratification, though the staining is probably secondary. Acid tests indicated that calcareous matter is present, but that it is not abundant.

These observations were made on the tunnel as seen on our first visit. Under the direction of Professor Holmes, Mr. Gerard Fowke later made a series of supplementary excavations in different directions to develop the formation further and secure additional fossils. A full statement of the results will doubtless be given in Professor Holmes's report. He has kindly permitted me to use such of the data thus gathered as are serviceable in the geologic determinations. Without entering upon precise details, it will suffice here to say that the tunnel was extended

southward until the rising of the Carboniferous beds in the bottom made further extension in that direction unpromising. Only a few feet beyond the end of the original tunnel Carboniferous shale was found overlying the heavy stratum of limestone, and the surface of this rose as though the foot slope of the ridge had been reached. The correctness of this inference is scarcely open to question as the whole environment supports it so strongly that it had been anticipated. The ease with which this shale was eroded, compared with the underlying limestone, readily explains the flat limestone surface on which the tunnel was run.

In an excavation on the west side of the tunnel, a shallow trench was found in the upper surface of the limestone running nearly parallel with the tunnel and also parallel to the axis of the adjacent ravine. With little doubt this trench was the axis of the ravine in the erosion stage just preceding the filling up of the ravine by the relic-bearing deposit. This further aids in explaining the nearly horizontal, but slightly rising, base of the tunnel, since it locates it alongside the axis of the ravine on a resistant bed (see Fig. 13.)

An offset tunnel at right angles to the original tunnel was run eastward eleven feet from the place of the adult skeleton. It developed about four feet of disturbed shale and mixed débris in its base, the vague structure lines of which dipped eastward irregularly. It had the appearance of a talus slump that had crept down the slope of the adjacent rock surface, and warped and slightly tilted itself backwards according to a common habit of such masses. This doubtless took place before the upper deposit was laid upon it and while yet the ravine was open, *i. e.*, about the close of the erosion stage. In the east end of this offset, the silty formation has been slightly fissured along a nomber of lines by tensional action and the little crevices filled with a grayish-white soft deposit that effervesced very promptly with acid, implying calcium carbonate. The riveing tension probably came from the tendency of the mass to creep on the underlying rock surface, since this rises to the east and so furnishes a sloping base of shale which arrests the waters descending through

the more porous mass above and which, thus becoming wet, presents an unctuous slippery surface favorable to creep.

On the west side of the tunnel the excavation was carried from near the point where the fragment of the child's jaw was found westward at right angles and was met by an open cut from

FIG. 11.—View from the westward showing the trench dug by Mr. Fowke from the ravine toward the tunnel with which it connects below. The original tunnel runs from left to right under the two trees seen beyond the end of the cut. The child's jaw was found at the intersection of the cut (extended by tunnel below) with the original tunnel just at the left of the trees. The adult skeleton was found nearly under the second light spot to the right of the two trees.

the ravine. This open trench (Figs. 11 and 12) afforded an admirable opportunity to study the constitution and structure of the whole section from the rock floor to the surface through a depth of about twenty feet. The definite clayey band found near the base in the tunnel is here wanting. As noted above, it pinches

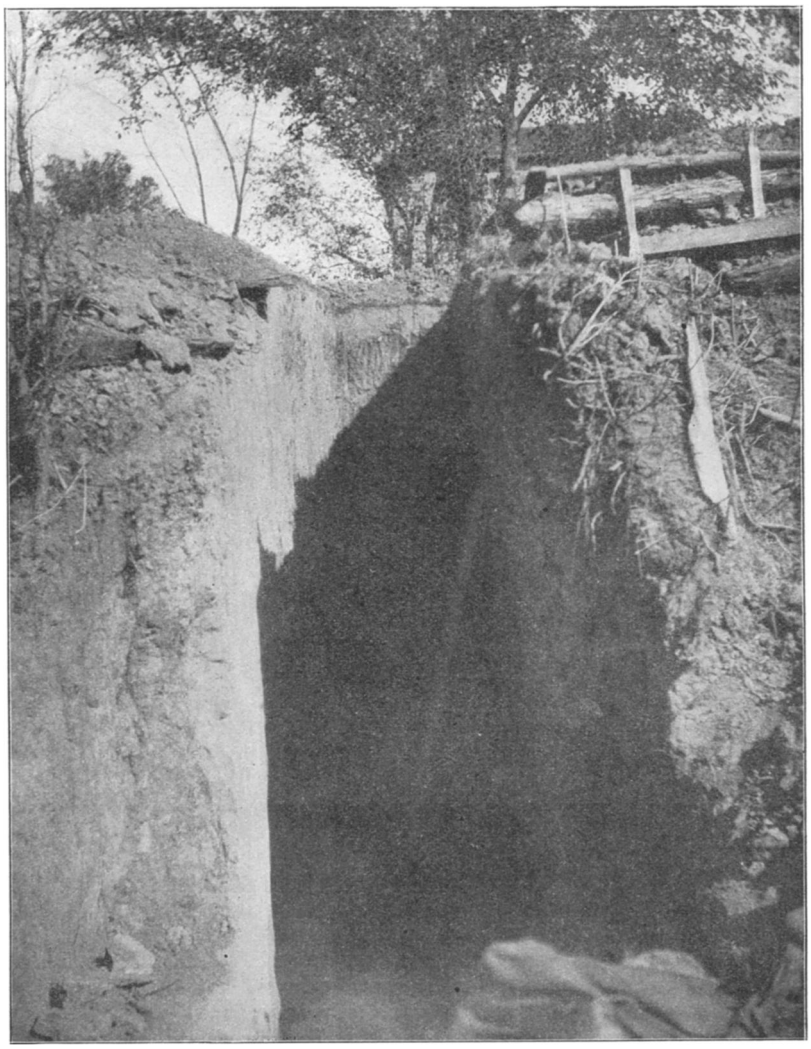

FIG. 12.—Nearer view of the open cut shown in Fig. 11. The shadow obscures the larger portion, but the lighted portion on the left shows the absence of definite stratification, and indicates something of the mottled character of the deposit.

out irregularly a short distance west of the original tunnel. Putting all the facts together, it would seem that this little stratum was laid down in the axis of the ravine shortly after the stage of aggradation began. As it scarcely reaches three inches in depth at its thickest point—averaging probably less than an inch—and is very homogeneous and peculiar, as well as very fresh and calcareous, it was probably formed at a single stage of inundation. Aside from this there is no distinct stratification or lamination in the whole section, nor any complete assortment of the material. The main material is a silt somewhat closely resembling loess; but unlike it in the particulars already pointed out. Through this silt, at all heights from the base to the surface, there are dispersed fragments of limestone, shale, and other débris incompatible with a typical loess deposit. The limestone fragments were sometimes several inches across. Mr. Fowke, who gave careful attention to the distribution of this material, affirms that it was found indifferently at all heights, and I carefully verified this by an examination of the walls of the deep open cut. Small fragments of softened limestone were so abundant in some parts that the walls were mottled with the white chalky spots made by the spade in mashing and spreading them. There were also many bits of shale ranging up to an inch in length, not a few of which had been sufficiently weathered to be yellowish or brownish. These also occurred high up as well as low down in the section.

I have said that there was no distinct stratification, lamination or assortment in the section. There was some aggregation of the silt and the fragmental material. There were spots where the shaly and limy débris was sufficiently abundant to lend a gravelly aspect to the mass, but close inspection showed that it was not really assorted, laminated, or stratified. The agency of accumulation had obviously brought relatively more fragmental débris to these portions, or at least had left relatively more fragmental débris in these portions, than in average portions, but the aggregation did not rise to the grade of typical assortment and lamination. That it is a wash product seems to me clear, but not a stream deposit nor a lake deposit, nor any other form of

purely subaqueous deposition. I should identify it as a typical aggradation deposit of the ravine and basal-slope type where the hillside environment was Carboniferous limestone and shale mantled with loess.

A few pebbles of drift and not a few pieces of charcoal were found in the section, the latter at different horizons. Many land shells and some additional bones were also found by Mr. Fowke, but no unios. These interesting features will doubtless be described in Professor Holmes's report.

As had been anticipated, the excavations show that the extent of the deposit is limited, and that it was penetrated by

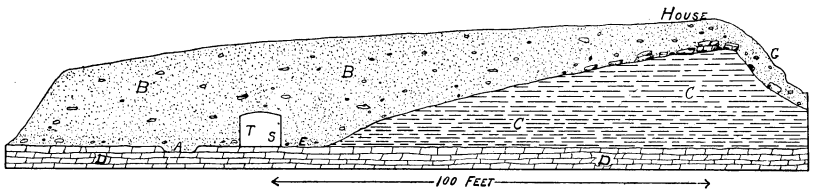

FIG. 13.—Cross-section from ravine at the left to truncated face overlooking the Missouri bottoms (*G*) on the right. The section passes through the end of the original tunnel (*T*) at the place of the adult skeleton (*S*). It shows the supposed original trench of the ravine in the surface of the limestone (*A*), the shale overlying the limestone, developed in the cistern and in the extension of the tunnel (*C*), the limestone blocks of the upper limestone under the house, and the deposit overlying the relics (*B*). The line marked 100 feet represents the distance from the place of the skeleton to the point where the truncated slope begins, not the whole length of the section.

the tunnel nearly or quite at its greatest depth. Rock comes to the surface just back of the house, and in the excavation for the rear end of the house, Mr. Concannon informed me that he reached rock which he thought was of the regular quarry kind. In sinking for a cistern eighteen feet deep on the east side of the house, he went through about four feet of dirt, then about two feet of loose limestone blocks, and then about twelve feet of "soapstone," so hard that he had to blast it. This is undoubtedly the Carboniferous shale encountered by Mr. Fowke in the extension of the tunnel. This makes it clear that the spur on which the house stands is formed mainly of Carboniferous beds and is merely mantled with the silt and débris formations. The accompanying cross-section is drawn approximately to a true

scale (Fig. 13) and shows the probable limitations of the deposit. The extension of the tunnel shows that it thins to the southward, while the ravine intercepts it on the west.

The surface configuration is that of a combined basal-slope and ravine-bottom deposit, *i. e.*, of aggradation in the bottom of the ravine, combined with deposits lodged on the lower slopes in adjustment to the aggraded bottom. The structure of the deposit is in keeping with this interpretation. The little layer of calcareous clay in the tunnel seems to imply deposition in standing, or slowly moving water, *i. e.*, a valley-bottom deposit, probably a back-water deposit. The absence otherwise of definite stratification or assortment of the material, and its complete resemblance to secondary slope accumulations derived jointly from the loess and the underlying beds seems to require its reference to aggradational action. Professor Williston found the cast of a clam shell with attached valves in the angle between the wall and the roof of the tunnel about seven feet from the base. In the absence of satisfactory evidences of fluvial action at this height and in the presence of human relics, this may well be referred to human agency.

INTERPRETATIONS.

The case is perhaps not an absolutely declared one, and a wholly unreserved interpretation may not be warranted, but a very strong balance of evidence seems to point in a specific direction. Certain things seem to me clear :

1. The deposit is not true original loess. It is a mixture of loess-like silt, Carboniferous detritus, water-laid clay and other débris. The Carboniferous detritus was obviously derived from the adjacent strata, in part by disintegration, in part by wear, and in part by fracture without much rounding. The loess-like silt was probably derived in the main by wash from the loess mantle of the adjacent hills, but in part also by winds from the Missouri bottoms ; possibly also in part by creep. Its character implies that some of the silt was brought to its present position without complete leaching, while most portions show evidences of exposure and weathering. From such differences

of history probably arose the variations in color, texture and effervescence in response to acid, which were observed. The material of the one distinctly water-laid layer was probably derived from the Carboniferous shales at some special stage of erosion and inundation — some unusual storm and flood, perhaps — and was deposited without weathering, and remained undisturbed except on its borders.

2. The truncated faces of the adjacent Missouri bluffs, and the numerous slides on these faces, show that the Missouri river has worked extensively and effectively across the mouth of the tributary only a few rods from the site of the relics, and that this has been comparatively recent.

The rather steep slopes of the tributary valley favor the view that the *present fashioning* of these is recent. The main excavation of the valley probably dates back to the post-Kansan erosion interval, and this was perhaps preceded, and perhaps determined, by a preglacial valley. But the valley, *as it is now fashioned*, is pretty closely adjusted to the Missouri river bottoms which are features of recent origin, and *this adjustment and the slopes and deposits involved in it* is, by rather strong presumption, to be connected with the development of the adjacent Missouri channel. The age of the original valley and of the upland mantles does not concern us here, unless these lower deposits, well down in the axis of the valley, and at its junction with the great river bottoms, are surely inheritances from the older period, and not adjustment phenomena.

3. The record of these earlier events is here very imperfect. Even the record of the more recent of the Pleistocene events is very scant where it should be abundant and decisive if the conditions of preservation had been favorable. In Dakota, where the Missouri river came into relation with the last stages of general glaciation within its basin, there are three great systems of terraces as worked out by Todd,[1] viz.: 1) "The higher bowldery terraces," varying from 500 feet to 350 feet above the Missouri and connected with the outer moraine of the Wisconsin stage; 2) "The lower bowldery terraces," varying from 350 feet to

[1] TODD, *Bull. U. S. Geol. Surv.*, No. 158, pp 128–154.

various lower levels at different points, and connected with the second moraine of the Wisconsin stage, and 3) a complex system of "silt terraces" ranging from 150 feet downward, three or four of these terraces often occurring at the same locality. These last have not been traced into physical continuity with any of the moraines, and doubtless represent in part the very latest stages of glaciation, and in larger part the postglacial stages ranging down to very recent times. A reference to Todd's descriptions will show that these are not mere strands or slender benches on the valley sides, but great platforms, sometimes a mile or two broad. Now all of these three systems, so magnificently developed in Dakota, should ideally be represented in some way at the Lansing locality, but we have only the obscure, sloping shoulders already described, and the little deposit containing the relics. There is no sign that these belong to the first or second of the Dakota series which are directly connected with the first and second stages of the Wisconsin glaciation. In Dakota these terraces are formed of very coarse material, which gives them the title "bowldery," and this implies strong currents fed by glacial débris. Normally, these high bowldery terraces should graduate down-stream into finer gravels, sands and silts, all bearing the distinctive marks of their glacio-fluvial origin. The relic-bearing deposit is not of this type, and is not overlain by this type. The most natural inference then is that the train of glacial gravels, sands and silts borne away by the Missouri waters from the ice edge in the more vigorous stages of Wisconsin glaciation was carried away from this part of the Missouri channel before the relic deposits were formed. This is the more to be supposed because the Missouri has here recently run hard against the highlands and truncated them, and the tributary valleys are steep and in this special case, short and rather sharp. Remnants of the true glacio-fluvial deposits in this portion of the Missouri river are rare, and an experienced Pleistocene geologist familiar with their habit would not expect to find them in the mouth of so narrow, steep-sided, and steep-bottomed a tributary as that at Concannon's. The probable reason for the scantiness of the glacio-fluvial record in this part

of the Missouri valley has been given in the preliminary considerations. If neither of the strong bowldery terraces of so late a stage of glaciation as the Wisconsin are represented at the site of the burial, there is but scant ground to assume that the earlier and much feebler and much more erosible glacio-fluvial deposits of the Iowan are preserved.

The natural conclusion is, therefore, that the little relic-bearing deposit in the valley at Concannon's belongs either to the same class as the silt terraces of Dakota, to which it bears a measure of resemblance, or to some later stage.

Specific views.—While, as before remarked, the case is perhaps not a wholly declared one, and an unqualified identification may not be entirely warranted, the range of tenable interpretation seems to me to lie within narrow limits.

1. *The most conservative and the most probable view.*—All the essential facts known to me seem to be explicable on the following lines which involve the minimum of action and of assumption, and which appeal only to the natural order of things. The first stage of essential action is assigned to a time when the channel of the Missouri river ran immediately past the mouth of the tributary valley and was higher than now to such an extent as to be in erosive adjustment with the tributary at the top of the rather heavy limestone layer which lies just below the tunnel. It has already been noted that where a strong stream like the Missouri passes hard by the mouth of such a tributary, two effective conditions of erosion are supplied. The tributary has a low point of discharge and hence a high gradient, and its detritus is immediately swept away by the great river. During this stage the rock surface under the relic-bearing deposit was developed by the removal of the shales above, and the lower slopes adjacent were measurably denuded because the conditions were favorable to erosion and the shales were easily cut away. After a stage of erosive adjustment of this kind, a change of relations was brought about by the diversion of the channel of the Missouri river to some other portion of the broad valley, attended by the substitution of a flood plain at the mouth of the tributary. As the vertical range of water is now twenty feet or more,

the building up of a normal upper flood plain that much above the preceding erosion plain may be assumed. This must have been accompanied by a filling up of the lower part of the tributary in like measure. More than this, if the diverted stream in its new course ran on the opposite side of the bottoms, two miles away, the tributary might have also built a fan on the surface of the flood plain, with proportional further aggradation within its mouth. Now this filling up of the axis of the valley to the amount indicated, changed the condition of the lower sides of the valley, and these became covered with lodgment deposits derived from the upper slopes and with silts blown up from the Missouri bottoms, an action still in effective operation. Such deposits are the normal result of an effort to establish a new set of gradients adjusted to a lifted axis. The deposit resulting from these combined agencies should be just such a mixed nondescript one as the actual case presents, viz., a little clear stratification in the lower part, some suggestion of stratification of an uncertain sort in the other portions, but no complete stratification or assortment; a general absence of declared structure, some limestone débris, some shale débris, a little drift, some loess wash, some soil wash, with land shells, some stream or back-water silt, with river shells—perhaps humanly introduced—and some wind silt; and hence, some portions unleached and others leached, with other variations from a typical unitarian deposit, such as true alluvium on the one hand, or typical loess on the other. It seems to me that the depth of the deposit is quite within the competency of this method, while its general configuration and aspect are in close accord with this interpretation. Under this view the burial of the human remains took place either during the latest phases the erosive process of the stage indicated, or in the early phase of the building of the flood plain. The antiquity of the burial is measured by the time occupied by the Missouri river in lowering its bottoms, two miles more or less in width, somewhere from fifteen to twenty-five feet, a very respectable antiquity, but much short of the close of the glacial invasion.

2. *Possible but not probable interpretations.*—As previously

indicated, the case is not so declared as to render a given interpretation wholly certain, and to absolutely exclude all others. While I think them quite improbable, other times and methods of burial may be entertained as within the bare limits of possibility.

1) As noted in the description, there are some small and obscure shoulders or terraces at different heights up to sixty feet above the upper flood plain of the Missouri river. It is not clear that the higher of these are anything but degradational inequalities of structural origin, but it may be worth while to recognize that these features may possibly be of fluvial origin, and may be genetically connected with the lower deposit containing the human relics, though there is no clear evidence of this. In this case the working level of the river must be placed at perhaps sixty feet above that of the present day, and its waters must be supposed to have invaded the mouth of the valley more extensively and deeply. The site of the relics is thus placed in the bottom of the ancient river, though not in its main channel. It was therefore, more or less subject to the scouring action of the river bottom, and to alternate deposition and removal, as set forth in the preliminary considerations. At any stage during such submersion, when the current of the river was directed against the mouth of the tributary, it would be theoretically possible for the pre-existing deposit to be scoured out and replaced in the manner so constantly illustrated by the present action of the river, and in connection with such removal and refilling, the relics could be introduced. This would place the time of their burial farther back, but probably not so far as even the latest stage of the last ice invasion.

The specific character of the deposit does not seem to me to lend support to this interpretation. It is not distinctly and specifically fluvial, as it might be expected to be if formed in the bottom of the river or in deep and constant water of any kind, It bears the aspect of a mixed combination product, such as postulated in the previous interpretation.

2) It may be held that the relics were buried in the early stages of the Wisconsin glaciation, when the Missouri river was

rising because of the filling of glacial wash poured into it at the north. In this case it would be assumed that the tributary valley had previously been fashioned as it is now, that with the filling up of the Missouri valley it also became filled in the lower part, involving the burial of the relics, and that with the lowering of the Missouri since the glacial period, it has been re-excavated to its present extent. In this case the filling should have combined the characters of a glacio-fluvial deposit and a back-water deposit. The actual deposit does not seem to me to be of this kind. The present adjustment of the tributary to the Missouri river must also, in this case, be regarded as an accident, however improbable.

3) It has been held by Upham and Winchell that the loess-like deposit covering the relics is a part of the sheet of loess that mantles the uplands of this region generally, and is referred to the Iowan stage of glaciation, and that the relics were buried in the early stages of this accumulation, or earlier. This view receives more apparent than real support from the partial resemblance of the upper part of the deposit to loess. As already stated, this does not seem to me to be true original loess, either of the upland or of the fluvial type, but a secondary deposit, in part, and only in part, derived from the loess. If so, its age is that of its derivation, not that of the parent loess. Very similar deposits seem to have been formed at all ages since the main loess epoch, and are being formed now, and apparently must continue to be formed as long as the general loess mantle remains the chief source of erosion and re-deposition, but these deposits generally betray their origin by their secondary characters, as in this case.

4) It is even possible to regard the limestone débris in which the skeleton was found as preglacial detritus, buried first by the Kansan drift, which was afterward eroded, and then by the loess-like deposit; but in the first place, the detritus is not of the distinctive residual surface type, since it is not thoroughly weathered and leached as such deposits usually are, and in the second place, the hypothesis assumes that the post-Kansan erosion was adjusted to the preglacial erosion with a degree of

nicety quite improbable, and in the third place, the view leaves very little erosion and deposition to be referred to the long, subsequent stages, and in the fourth place, it leaves the adjust, ment of the tributary to the Missouri a matter of accident, and two accidents of nice adjustment in one hypothesis are somewhat too many.

5) At the other extreme, it is perhaps possible to refer the burial to very modern action of the Missouri waters at a very exceptionally high stage, combined with deposition by the tributary, aided by slope wash and creep and wind work from the Missouri bottoms. This seems to me, however, to be pressing agencies to the limit of their possibilities rather than resting with their probabilities within the limits of their more habitual action.

Without holding it to be quite demonstrable, it seems to me that the weight of evidence is very strong in favor of the first and most conservative interpretation, which finds an apt and adequate explanation in the natural order of things.

In this connection, I beg to invite the attention of archæologists to the slight grounds for hope of finding really strong evidences of man's antiquity in the fluvial deposits of the glacial rivers, because of the liability of these deposits to deep overworking by scour-and-fill. On the Ohio, for example, the floods are today boring out deep holes in the river and shortly filling these again, only to bore and fill somewhere else. It would doubtless not be difficult to sow coins of this year's mint over the bottom of this river in such a way that a decade hence they would be buried a score or some scores of feet in gravel and sand; and what is more, this gravel and sand would be of the glacio-fluvial type, since it would be only the true glacio-fluvial material rearranged by stream action not unlike that which originally formed it. It would hence be stratified, and nearly or quite indistinguishable in small sections from the original. The same process has been in progress ever since the river began to erode the glacial filling. If its early meanders covered the whole of the original glacial flood plain, no part of it would be exempt from the suspicion of such overworking and natural intrusion.

It thus appears that even if the burying gravels were of glacial aspect, and the burial were a score or two score, or perhaps even three or four score feet deep, it would require careful circumspection to remove legitimate and necessary doubts arising from this source. This might be done in special cases on geologic grounds, and the nature of the human deposit might in other cases help to eliminate these sources of doubt, but special and strong evidence of this kind is required to make a good case.

So far as the glacial ages are concerned, evidence of man's presence should be sought rather in the interglacial than in the equivocal fluvial deposits. With careful identification and reasonable circumspection, all sources of doubt as to age could be removed from the intercalated deposits of the interglacial epochs, and as these carry the relics of other life, they are competent to carry those of man if he really lived in the region at the time.

I am permitted to add the following notes by Professor Calvin and Professor Salisbury, who examined the deposit with me, and who have been kind enough to read and criticise my manuscript, as prepared before my second visit. The observations of that visit strengthened the grounds on which they have indicated slight divergencies from my views.

T. C. CHAMBERLIN.

STATEMENT OF PROFESSOR CALVIN.

I thank you for the opportunity you have given me to read the manuscript of your paper on "The Geologic Relations of the Human Relics of Lansing, Kan." I wish to thank you further, not for myself alone, but on behalf of all geologists engaged in the study of problems similar to the one under discussion, for the full and clear presentation of the behavior of rivers of the Missouri type in connection with migrations of their meanders, of their work in degradation and aggradation, in scour-and-fill, while deepening and widening their valleys, and of the changing conditions which they impose on their tributaries. The application of the principles discussed in the preliminary part

of the paper to the interpretation of the deposit in which the human bones were found near Lansing, Kan., as given in your Interpretation 1, seems to fit the case and harmonize all the facts in a very admirable way. If I were to dissent at all from your conclusions as stated in Interpretation 1, it would simply be to the extent of saying that a lowering of the Missouri valley since the bones and associated silts were deposited, through a space somewhat less than fifteen or twenty-five feet, would probably be amply sufficient.

SAMUEL CALVIN.

STATEMENT OF PROFESSOR SALISBURY.

With the general conclusion of the above paper as expressed under the heading, "The most conservative and the most probable view," I am in perfect accord. If I have any suggestions to add, they are the following:

1. Aside from the distinct layer of clay in one wall of the tunnel, I saw no structure which could properly be called stratification.

2. The band of water-laid clay seemed to me to imply stagnant or essentially stagnant water. I am disposed to refer its origin to a time when high water in the Missouri ponded the tributary. Since the level of the clay is but a few feet above the historic high-water mark of the river, the stream need not have been flowing more than a few feet above its present level when the clay was deposited. I see no reason for supposing that the introduction of the skeleton and the deposition of the clay were far separated in time.

3. The unequivocal layer of water-laid clay seems to me strong evidence against the view that the material in which it occurs is referable to any of the recognized loess epochs. I have seen thousands of sections of loess, but never one with such a seam of clay.

4. I regard the presence of the unio shell as evidence that the loess in which the tunnel is dug is not in its original posi-

tion. I am not aware that a unio shell has ever been found in undisturbed loess. The presence of the shell in *loess talus*—for that seems to me the proper characterization of the material in which the human relics were found—could be readily accounted for in various ways, one of which is suggested in the preceding pages.

ROLLIN D. SALISBURY.